Exploring the Lower Atmosphere: A White Paper for Strategic Focus Area 8

Submitted by:

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Even on the Earth, there is currently an inadequate density of measurements of lower tropospheric chemistry to permit high resolution modeling of tropospheric chemistry and fluxes from the surface to the boundary layer. These environmental data are critical to developing the relationships between natural and anthropogenic emissions at local scales and planet-scale phenomenology, as well as adequate exposure information to perform regional to local risk analysis and management at high confidence levels. Current satellite technologies cannot fill this information gap for either scientific or regulatory purposes. A measurement technique is needed to characterize this highly active and complex area and to improve process knowledge of the interactions between the atmosphere and the land and water surfaces. On the Earth, measurements are particularly needed in coastal environments and complex terrain, where over half the population lives, and where models perform most poorly. Measurements of ozone and particulates are deemed to be priority one and two, respectively, by the US Environmental Protection Agency Office of Air Quality Planning and Standards for the protection of human health. Additionally, on other planets, explorers will need this site specific, high density information to plan for robotic, and especially human, survival.

UAV platforms, operating at relatively low altitudes (near 10,000 ft above ground level), and using laser-based monitoring systems have great promise to rapidly fill this gap. Doppler laser wind mapping, combined with Differential Absorption Light Detection and Ranging (DIAL), can provide hourly wind field and chemical composition profiles over large areas at very high spatial resolution. These data can be used to improve, validate, and set boundary conditions for high resolution models at local to regional scales. Mission durations of 1-5 days could cover Earth-atmosphere episodes at regional scales. This would be especially useful for high priority ozone and particulate monitoring, but would be useful for other gasses, as well. Flux measurements as well as gasses without strong absorption spectra, could be measured using small UAV's configured with *in situ* instruments operating in coordinated patterns at very low altitudes (below 4,000 ft above ground level).

USEPA, NOAA, and NASA have extensive experience with DIAL, and Laser Atmospheric Wind Sounding was planned in the early 1990s as part of the Earth Observing System. The three agencies also have extensive atmospheric modeling and data assimilation experience which would directly benefit from the increased density of measurements afforded by this technique. Lower tropospheric measurements of atmospheric chemistry could fill the gap between measurements from the existing Aura satellite and the existing EPA, state, and foreign *in situ* monitoring networks to provide critical high density measurements to improve both regulatory and climate change models. Fielding these measurement suites from UAVs avoids the technical

difficulties and costs associated with operating laser systems in space, provides focused, event driven, high resolution data, and will develop the techniques required for detailed atmospheric information on Mars and other planets.